PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G01J 5/20, H01L 31/0216

A1

(11) International Publication Number: WO 00/33040

(43) International Publication Date: 8 June 2000 (08.06.00)

(21) International Application Number: PCT/KR98/00382

(22) International Filing Date: 27 November 1998 (27.11.98)

(81) Designated States: CN, JP, RU, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

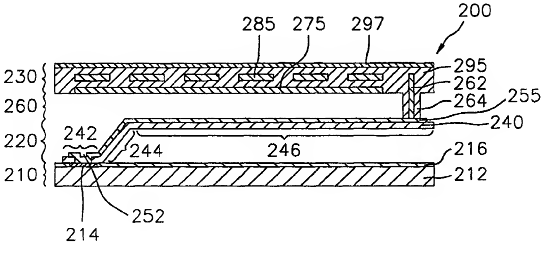
Published
With international search report.

(71) Applicant: DAEWOO ELECTRONICS CO., LTD. [KR/KR]; 541, 5–Ga, Namdaemoon–Ro, Jung–gu, Seoul 100–095 (KR).

(72) Inventor: YONG, Yoon, Joong; Video Research Center, Daewoo Electronics Co., Ltd, ., 541, 5–Ga, Namdaemoon–Ro, Jung–Gu, Seoul 100–095 (KR).

(74) Agent: JANG, Seong, Ku; 275, Yangjae–dong, Seocho–gu, Seoul 137–130 (KR).

(54) Title: BOLOMETER WITH A ZINC OXIDE BOLOMETER ELEMENT



(57) Abstract

An inventive infra–red bolometer (200) includes a zinc oxide bolometer element to obtain a stability in the high–temperature process and a high sensitivity. The bolometer comprises an active matrix level (210), a support level (220), a pair of posts (260) and an absorption level (230). The active matrix level (210) includes a substrate (212) having an integrated circuit, a pair of connecting terminals (274) and a protective layer (216) covering the substrate. The support level (220) includes a pair of bridges (240), each of the bridges (240) being provided with a conduction line (255) formed on top thereof, wherein one end of the conduction line (255) is electrically connected to the respective connecting terminal (214). The absorption level (230) includes a zinc oxide (ZnOx) bolometer element (285) surrounded by an absorber (295). Each of the posts (260) includes an electrical conduit (262) surrounded by an insulating material (264) and is placed between the absorber and the bridge, in such a way that the zinc oxide bolometer element (285) is electrically connected to the integrated circuit through the electrical conduit (262), the conduction line (255) and the connecting terminal (214).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

BOLOMETER WITH A ZINC OXIDE BOLOMETER ELEMENT

TECHNICAL FIELD OF THE INVENTION

The present invention relates to an infra-red bolometer; and, more particularly, to the infra-red bolometer incorporating therein a zinc oxide bolometer element.

BACKGROUND ART

A radiation detector is a device that produces an output signal which is a function of the amount of radiation that is incident upon an active region of the detector. Infra-red detectors are those detectors which are sensitive to radiation in the infra-red region of the electromagnetic spectrum. There are two types of infra-red detectors, thermal detectors including bolometers and photon detectors.

The photon detectors function based upon the number of photons that are incident upon and interact with electrons in a transducer region of the detector. The photon detectors, since they function based on direct interactions between electrons and photons, are highly sensitive and have a high response speed compared to the bolometers. However, they have a shortcoming in that the photon detectors operate well only at low temperatures necessitating a need to an incorperate therein an additional cooling system.

The bolometers function, on the other hand, based upon a change in the temperature of the transducer region of the detector due to absorption of the radiation. The bolometers provide an output signal, i.e., a change in the resistance of materials (called bolometer elements), that is proportional to the

temperature of the transducer region. The bolometer elements have been made from both metals and semiconductors. In metals, the resistance change is essentially due to variations in the carrier mobility, which typically decreases with temperature. Greater sensitivity can be obtained in high-resistivity semiconductor bolometer elements in which the free-carrier density is an exponential function of temperature.

In Figs. 1 and 2, there are shown a perspective view and a cross sectional view illustrating a three-level bolometer 100, disclosed in U.S. Ser. Application No. ____________________ entitled "BOLOMETER HAVING AN INCREASED FILL FACTOR". The bolometer 100 comprises an active matrix level 110, a support level 120, a pair of posts 170 and an absorption level 130.

The active matrix level 110 has a substrate 112 including an integrated circuit (not shown), a pair of connecting terminals 114 and a protective layer 116. Each of the connecting terminals 114 made of a metal is located on top of the substrate 112. The protective layer 116 made of, e.g., silicon nitride (SiN_x), covers the substrate 112. The pair of connecting terminals 114 are electrically connected to the integrated circuit.

The support level 120 includes a pair of bridges 140 made of silicon nitride (SiN_x), each of the bridges 140 having a conduction line 165 formed on top thereof. Each of the bridges 140 is provided with an anchor portion 142, a leg portion 144 and an elevated portion 146, the anchor portion 142 including a via hole 152 through which one end of the conduction line 165 is electrically connected to the connecting terminal 114, the leg portion 144 supporting the elevated portion 146.

The absorption level 130 is provided with a serpentine bolometer element 185 surrounded by an absorber 195 and an IR absorber coating 197 formed on top of the absorber 195. The absorber 195 is fabricated by depositing silicon nitride before and after the formation of the serpentine bolometer element 185 to surround the serpentine bolometer element 185. Titanium (Ti) is chosen as the material for bolometer element 185 because of the ease with which it can be formed.

The resistance in the titanium bolometer element 185, as shown in Fig. 3, exhibits a positive, linear dependence on temperature. The temperature coefficient of the resistance (TCR) of the titanium bolometer element 185 is 0.25% K^{-1} at 300 K.

Returning to Figs. 1 and 2, each of the posts 170 is placed between the absorption level 130 and the support level 120. Each of the posts 170 includes an electrical conduit 172 made of a metal, e.g., titanium (Ti), and surrounded by an insulating material 174 made of, e.g., silicon nitride (SiN_x). Top end of the electrical conduit 172 is electrically connected to one end of the serpentine bolometer element 185 and bottom end of the electrical conduit 172 is electrically connected to the conduction line 165 on the bridge 140, in such a way that both ends of the serpentine bolometer element 185 in the absorption level 130 is electrically connected to the integrated circuit of the active matrix level 110 through the electrical conduits 172, the conduction lines 165 and the connecting terminals 114. When exposed to infra-red radiation, the resistivity of the serpentine bolometer element 185 increases, causing a current and a voltage to vary, accordingly. The varied current or voltage is amplified by the integrated circuit, in such a way that

the amplified current or voltage is read out by a detective circuit (not shown).

There are certain deficiencies associated with the above described three-level bolometer 100. For example, during the formation of the absorber 195 made of silicon nitride (SiN_x), since silicon nitride (SiN_x) can be formed only at a relatively high temperature, e.g., over 850 °C, titanium (Ti) constituting the serpentine bolometer element 185 gets easily oxidized, which will, in turn, detrimentally affect the temperature coefficient of resistance (TCR) thereof. Further, since the bolometer element 185 is made of a titanium, the sensitivity of the bolometer 100 is less than desired.

DISCLOSURE OF THE INVENTION

It is, therefore, a primary object of the present invention to provide an infra-red bolometer including a bolometer element which is stable at high temperatures and has a high temperature coefficient of resistance (TCR).

In accordance with one aspect of the present invention, there is provided an infra-red bolometer, which comprises: an active matrix level including a substrate and at least a pair of connecting terminals; a support level provided with at least a pair of bridges, each of the bridges including an conduction line, one end of the conduction line being electrically connected to the respective connecting terminal; an absorption level including a zinc oxide bolometer element surrounded by an absorber; and at least a pair of posts, each of the posts being placed between the absorption level and the support level and including an electrical conduit surrounded by an insulating

material, each end of the bolometer element of the absorption level being electrically connected to the respective connecting terminal through the respective electrical conduit and the respective conduction line.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and features of the present invention will become apparent from the following description of the preferred embodiments given in conjunction with the accompanying drawings, wherein:

Fig. 1 shows a perspective view setting forth an infra-red bolometer previous disclosed;

Fig. 2 present a schematic cross sectional view depicting the infra-red bolometer shown in Fig. 1;

Fig. 3 exhibits resistance changes in the titanium bolometer element as a function of temperature;

Fig. 4 depicts a schematic cross sectional view setting forth an infra-red bolometer in accordance with the present invention; and

Fig. 5 provides resistance changes in the zinc oxide bolometer element as a function of temperature.

MODES OF CARRYING OUT THE INVENTION

There are provided in Figs. 4 and 5 a schematic cross sectional view setting forth an infra-red bolometer 200 and resistance changes in the zinc oxide bolometer element as a function of temperature in accordance with an embodiment of the present invention, respectively.

The inventive bolometer 200 shown in Fig. 4 comprises an active matrix level 210, a support level

220, at least a pair of posts 260 and an absorption level 230.

The active matrix level 210 has a substrate 212 including an integrated circuit (not shown), a pair of connecting terminals 214 and a protective layer 216. Each of the connecting terminals 214 made of a metal is located on top of the substrate 212. The pair of connecting terminals 214 are electrically connected to the integrated circuit. The protective layer 216 made of, e.g., silicon nitride (SiN_x) covers the substrate 212.

The support level 220 includes a pair of bridges 240 made of an insulating material, e.g., silicon nitride (SiN_x), silicon oxide (SiO_2) and silicon oxy-nitride (SiO_xN_y), wherein each of the bridges 240 has a conduction line 255, the conduction line 255 being made of a metal, e.g., aluminum (Al) or titanium (Ti), and formed on top thereof. Each of the bridges 240 is provided with an anchor portion 242, a leg portion 244 and an elevated portion 246, the anchor portion 242 including a via hole 252 through which one end of the conduction line 255 is electrically connected to the connecting terminal 214, the leg portion 244 supporting the elevated portion 246.

The absorption level 230 is provided with a bolometer element 285 surrounded by an absorber 295, an reflective layer 275 formed at bottom of the absorber 295 and an IR absorber coating 297 positioned on top of the absorber 295. The absorber 295 is made of an insulating material, e.g., silicon nitride (SiN_x), silicon oxide (SiO_x) or silicon oxy-nitride (SiO_xN_y), which is characterized of a low heat-conductivity. The reflective layer 275 is made of a metal, e.g., Al or Pt, and is used for returning the transmitted IR back to the absorber 295. The IR absorber coating 297 is

made of, e.g., black gold, and is used for reinforcing an absorption efficiency for the incident IR. When selecting a material for bolometer element 285, it is important to consider the material characteristics. The material, in addition to exhibiting a high temperature coefficiency of resistance (TCR), must be stable at high-temperatures since the silicon based materials used in forming the bolometers are usually formed at high temperatures. For this reason, zinc oxide is chosen as a material for the bolometer element 285 in the present ivention.

The conductivity of zinc oxide (ZnO_x) is dependent on its thickness and oxidation vacancy. Experimentally, it is found that the maxinum temperature coefficiency of resistance (TCR) is obtained in the zinc oxide bolometer element 285 when it has a thickness of 100Å - 10μm and molar-ratio (x) has a range of 0.5 - 1.5.

Fig. 5 provides graphically a relationship between resistivity and temperature of the zinc oxide bolometer element 285. The zinc oxide bolometer element 285 unlike the titanium bolometer element 185 of the prior art bolometer 100, exhibits a negative temperature dependence and the temperature coefficient of the resistance (TCR) of the zinc oxide bolometer element 285 is -2.75% K^{-1} at 300 K.

Returning to Fig. 4, each of the posts 260 is placed between the absorption level 230 and the support level 220. Each of the post 260 includes an electrical conduit 262 made of a metal, e.g., aluminum (Al) or titanium (Ti), and surrounded by an insulating material 264 made of, e.g., silicon nitride (SiN_x), silicon oxide (SiO_x) or silicon oxy-nitride (SiO_xN_y). Top end of the electrical conduit 262 is electrically connected to one end of the zinc oxide bolometer element 285 and bottom

end of the electrical conduit 262 is electrically connected to the conduction line 255 on the bridge 240, in such a way that both ends of the zinc oxide bolometer element 285 in the absorption level 230 is electrically connected to the integrated circuit of the active matrix level 210 through the electrical conduits 262, the conduction lines 255 and the connecting terminals 214. When infra-red energy is absorbed, the resistivity of the zinc oxide bolometer element 285 decreases which is read out by a detective circuit (not shown).

In the infra-red bolometer 200 of the present invention, the bolometer element 285 is made of a zinc oxide having a stability in high temperatures, which will, in turn, make the use of high-temperature processes possible during the fabrication of the bolometer 200. Further, the zinc oxide bolometer element 285 has a high temperature coefficient of resistance, giving a relatively high sensitivity to the bolometer 200.

While the present invention has been described with respect to certain preferred embodiments only, other modifications and variations may be made without departing from the scope of the present invention as set forth in the following claims.

What is claimed is:

1. A infra-red bolometer comprising:

an active matrix level including a substrate and at least a pair of connecting terminals;

a support level provided with at least a pair of bridges, each of the bridges including a conduction line, one end of the conduction line being electrically connected to the respective connecting terminal;

an absorption level including a zinc oxide (ZnO_x) bolometer element surrounded by an absorber; and

at least a pair of posts, each of the posts being placed between the absorption level and the support level and including an electrical conduit surrounded by an insulating material, each end of the bolometer element of the absorption level being electrically connected to the respective connecting terminal through the respective electrical conduit and the respective conduction line.

2. The bolometer of claim 1, wherein the zinc oxide bolometer element has a thickness of 100Å - 10μm.

3. The bolometer of claim 1, wherein the molar-ratio (x) has a range of 0.5 - 1.5.

4. The bolometer of claim 1, wherein the absorption level further includes a reflective layer and an IR absorber coating.

5. The bolometer of claim 4, wherein the reflective layer is formed at bottom of the absorber.

6. The bolometer of claim 5, wherein the reflective layer is made of aluminum (Al).

7. The bolometer of claim 4, wherein the IR absorber coating is formed on top of the absorber.

8. The bolometer of claim 1, wherein the conduction line and the electrical conduit are made of a metal.

9. The bolometer of claim 8, wherein the conduction line and the electrical conduit are made of Al, Pt or Ti.

FIG. 1
(PRIOR ART)

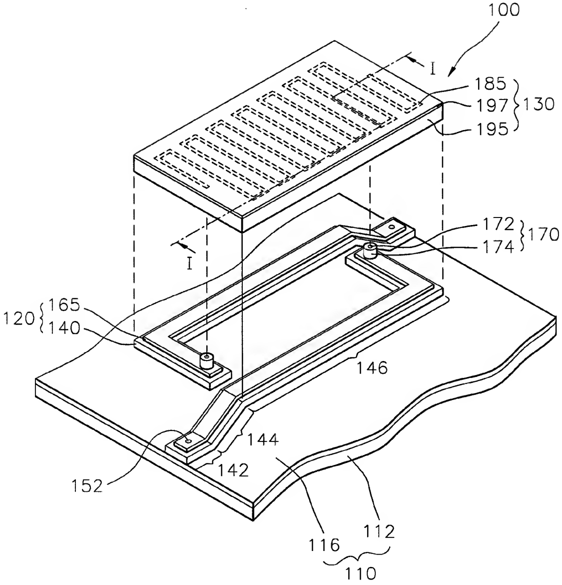


FIG.2
(PRIOR ART)

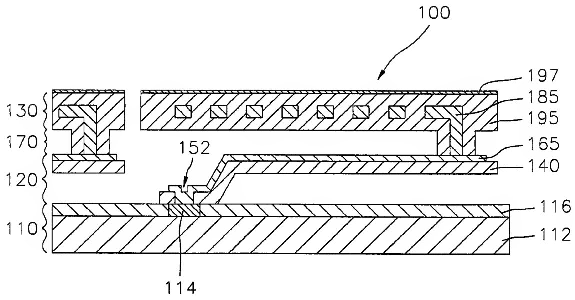


FIG. 3
(PRIOR ART)

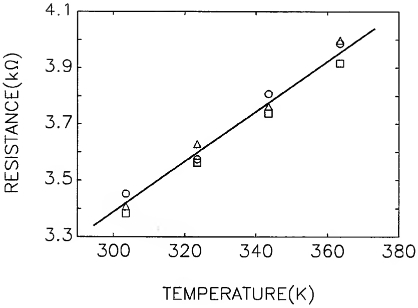


FIG. 4

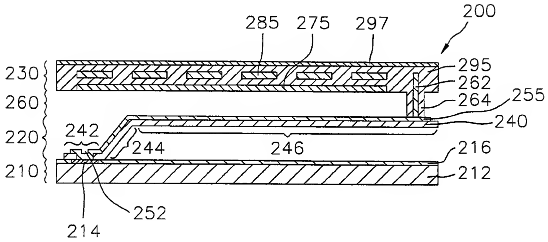
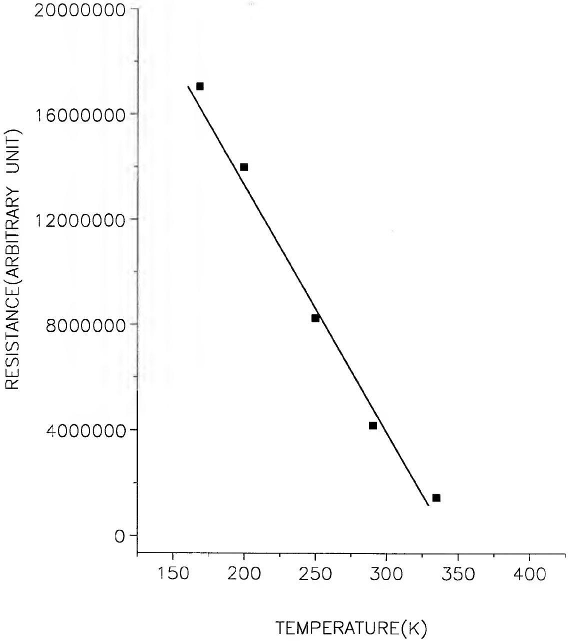

285
275
297
200
230
260
220
210
295
262
264
255
240
242
244
246
216
212
252
214

FIG. 5


20000000
16000000
12000000
8000000
4000000
0
RESISTANCE(ARBITRARY UNIT)
150
200
250
300
350
400
TEMPERATURE(K)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 98/00382

A. CLASSIFICATION OF SUBJECT MATTER

IPC^6: G 01 J 5/20; H 01 L 31/0216

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC^6: G 01 J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and. where practicable, search terms used)

WPI, EPODOC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 93/09 414 A1 (HONEYWELL), 13 May 1993 (13.05.93), page 4, line 4 - page 5, line 14; page 11, lines 9-13; fig.4-5c.	1-9
A	US 5 572 029 A (WACKER et al.), 05 November 1996 (05.11.96), column 9, line 46 - column 10, line 10; fig.3.	1,4,5
A	US 5 831 266 A (JEROMINEK et al.), 03 November 1998 (03.11.98), column 9, line 66 - column 10, line 14; column 11, lines 3-40; fig.4A-4F.	1,4,5

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
„A" document defining the general state of the art which is not considered to be of particular relevance
„E" earlier application or patent but published on or after the international filing date
„L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
„O" document referring to an oral disclosure, use, exhibition or other means
„P" document published prior to the international filing date but later than the priority date claimed

„T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
„X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
„Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
„&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 July 1999 (06.07.99)	01 September 1999 (01.09.99)
Name and mailing adress of the ISA/AT Austrian Patent Office Kohlmarkt 8-10; A-1014 Vienna Facsimile No. 1/53424/200	Authorized officer Bauer Telephone No. 1/53424/466

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR 98/00382

Im Recherchenbericht angeführtes Patentdokument Patent document cited in search report Document de brevet cité dans le rapport de recherche	Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
WO A1 9309414	13-05-1993	DE C0 69211153	04-07-1996
		DE T2 69211153	05-12-1996
		EP A1 611443	24-08-1994
		EP B1 611443	29-05-1996
		JP T2 7500913	26-01-1995
		US A 5293041	08-03-1994
US A 5572029	05-11-1996	US A 5574282	12-11-1996
		US A 5578826	26-11-1996
US A 5831266	03-11-1998	AU A1 39359/97	02-04-1998
		WO A1 9811411	19-03-1998